Billion Drop Technology Project:
Year 1

by

R. Barry Rogers, P. Eng.
President
Rogers Engineering Inc.
1510 Hilliard Street East
Saskatoon, Sask. S7J 0G4

Soils and Crops Work Shop
University of Saskatchewan
February 20 & 21, 1986

SUMMARY:
12 agricultural chemicals were applied with conventional and ultra small drops that increase coverage. 800025, 80015LP, and Air Jet .016TK3 tips were used to create drops from 130 µm MVD to 410 µm MVD to apply carrier rates from 10 L/ha to 100 L/ha, and chemical rates from 25% to 100% of recommended rates. In 1985, small drops and higher concentrations increased control susbstantially over large drops and lower concentrations, especially at lower carrier and chemical rates.

Billion Drop Technology

Introduction & Background

An Advantage for the Agricultural Sector

Agricultural weed researchers are finding that **ultra small drops and higher concentrations of chemicals in the carrier have a synergetic effect which increases chemical uptake.** Many isolated, but not conclusive studies, illustrate this. The development and use of this efficiency-increasing technology will reduce application rates and save large amounts of time and resources in the agricultural sector. The technology is based on the fact that by switching from 410 µm drops to 130 µm drops, the number of drops available to cover the plant is increased **31 times** or from 28 million to .9 **billion** drops per liter. This increase in coverage allows a reduction in carrier from 100 to 10 l/ha, with yet a 3 fold increase in the number of drops applied. The increase in chemical concentration helps to penetrate the leaf surface wax seal and increases chemical uptake. **This translates into an opportunity to save a farmer more than half his bill in chemical and application costs.**

The Health & Environmental View

Many farmers suffer from chemical sickness and high stress during the spraying season. The reduction in drift greatly reduces the amount of chemical that gets on the farmer, and consequently, his health improves. The spraying season is not as critical to the farmer as harvest and seeding. However, he often **suffers more stress during the spraying season.** This stress may be due to the effects of chemicals in the body and the uncertainty caused by the weather or stated in different words, his inability to manage his own time. This uncertainty causes severe mental stress in many individuals.

Environmentally, a **50% reduction of chemical applied to the field** is simply 50% less unnatural chemical and solvent that has to be broken down in the environment. Reducing the source of pollution is the best method of pollution control.

The Regulatory View

The concept that 130 µm drops increase efficacy is reasonably well accepted by researchers, but requires in-field demonstration on an overall scale to motivate the chemical regulatory process to put **Billion Drop** application rates on the label. The entire concept challenges the status quo of the pesticide application regulation system. Many individual regulators comment that the label requires the applicator to apply traditional amounts of pesticide and carrier and claim that we should not look at application rates that are not recommended on the label. They concoct various reasons not to look at small drop technology; this emphasises the need to demonstrate this new technology. We propose to demonstrate the advantage of BDT to the chemical companies, plus to the scientific and regulatory community who, we believe, will do their own research to confirm our findings. This would **provide impetus for the label change,** which is a requirement for the large scale acceptance of change by farmers. Some farmers reduce both carrier and chemical rates now, but since these reduced rates are not on the label, **the chemical companies do not warranty their chemical when it is applied with less than the label rates.** Also, the farmers do not receive the technical information they require to effectively apply chemical the most cost effective way. Efficiency is a necessity, considering the critical financial situation of the agricultural producing sector.

Research Summary

Minimum drop coverage required

Behrens found that droplet spacing had a pronounced effect on the herbicidal action of 2,4,5-T on cotton and mesquite seedlings. **Herbicidal activity increased rapidly up to 28 drops per square centimeter and only increased marginally above that.** Changing drop size from 200 µm to 800 µm had little effect, but higher concentrations increased the herbicidal effect.

Decreasing drop size range increases chemical efficacy

Reichard found that fan nozzles with **small drops gave increased penetration and kills** when applying paraquat to grass. Buehring consistantly had increased control from Fluometuron and MSMA from an **8001 nozzle, producing 375 µm drops** than from 600, 400 or 200 µm drops regardless of application rate and with variations from 47 to 281 l/ha.

Decreasing drop size increases coverage

Combellack and Richardson increased the under-100 µm drop size component of their spray from 8.1% to 28.3%. This resulted in an **increased spray capture of 238%**, and when turbulence was added, the capture increased by 300%. When the spray sheet angle was changed from vertical to 45° forward, the deposit increased by 60% on wheat, **186% on rye grass**, and 21% on radishes.

Plant stress increases required chemical application rates

Pchajek and Campbell found that the hydraulic fan nozzle gave as good or better results than the spinning disc when the same application rates were used. They achieved good control with low carrier and chemical rates, but found that under adverse conditions that the level of control was not adequate. To make the technology applicable in the field **the limitations Pchajek found need to be defined in terms that can be related to the field.**

Ultra small drop sprayer market

Micron Inc., Sprayrite, Tecnoma; B & D Enterprises (Sprafoil), Jetstream Machinery (Computer Spray), and Clark Inc. (Spray Coupe) market sprayers and are claiming indirectly through farmer testimonials that their units can attain effective kills with down to half the chemical recommended and one gallon of water per acre. Their claims are based on increased efficacy produced by small drops and improved coverage of the plants. Only Micron and Tecnoma attempt to control drift; the others are drift prone when compared to conventional sprayers. Only Micron has any scientific data to support their claim, but it is spotty. There are three companies rumoured to be developing shrouded sprayers in 1985. It is expected that most cereal sprayers will be shrouded in five (5) years.

Objective

Billion Drop Technology Project

To develop an agricultural chemical application technology, utilizing the increased coverage advantages of ultra small drops to acceptable pest control with 10% of the presently recommended carrier rate and 50% of the recommended chemical rate. This project will provide the **initial evidence required, along with research from others, to motivate both the chemical companies and regulatory people to change the chemical application label rates to include lower rates with small drop applicators**.

Method

Chemicals were applied at 0, 25, 50, 75 and 100% of the recommended rate with 10, 30, 50 and 100 L/ha of carrier (water) with 130 and 410 µm dia drops MVD. All tests were replicated 4 times on 3 x 5 meter plots. Only 2 meters in the plots were sprayed to allow for operational room and to give a check on each side of the sprayer. To get low application rates with large drops the sprayer was pulled up to 22 km/hr (see application table 1&2) with a Yamaha Quadrunner(Fig. #1), equipped with a speedometer that read to .1 km/hr (speed could be controlled to +/- .1 km/hr). The rear brake control was unhooked and used to control the on/off spray valve. To apply chemical with ultra small drops (130 µm) an enclosed boom is a necessity to prevent the drops from drifting away. Two of **Rogers Engineering's shrouded 2 meter plot sprayers**, plus a conventional sprayer were used in this project.

Liquid pressure was provided by a 2 kg CO^2 bottle c/w regulator and a plastic chemical bottle mounted on either the Yamaha or the shroud, depending on whether it was pushed or pulled. The boom was equipped with Dela-Fit diaphragm check valves to reduce dripping. The second shrouded sprayer was equipped with Air Jet tips AJ.016TK3, plus AJ.020TK5. Both the air and liquid pressure were derived from one CO^2 with two regulators. Both sets of tips were used to apply the 10 gal rate; valves were used to select the proper tip for lower rates(Table #1). Tips were placed in a patternator to check C.Vs. Air Jets were 8.8, 80015LP were 16.2 and 800025TC were 86 at 207 kpa, 50 at 410 kpa, and 34 at 690 kpa. The 800025TC is an airless paint spraying nozzle. Drop size was estimated from 800040 tip information.

Results

Roundup Study

In the 1985 Roundup Study, glyphosate was used as an indicator to illustrate the effect of small drops and higher concentrations. **Decreasing dilution of the chemical with carrier from 100 L/ha to 10 L/ha increased control on tame oats. Increasing drop numbers or decreasing drop size increased control.** Adequate control was achieved at 25% of the recommended rate of 1/3 L/ha for chem fallow with 800025TC tips (drops ≈ 180µm), and achieved with 30 L/ha and 50% of the recommended rate through 80015LP (drops 410 µm). Dust tracks were more prevalent in the lower chemical and carrier rate plots. Increasing either chemical or carrier (carrier could be increased only slightly before dilution would reduce the effect) rates would diminish the tracks. The low application rates were applied with 800025TC tips (Spraying Systems), the large drops with 80015LP tips. Spraying Systems' Air Jet (AJ.016TK3) tips (drops 130 µm MVD) were also tested, but did not give comparable control to the 800025TC tips. Operational problems may have been responsible for the lack of control. The test will be repeated in 1986.

The 800025TC tips had a C.V. of 50 at the pressures and nozzle-to-target distances used in this test. No indication of uneven application appeared in the plots. Since we currently recommend using tips with C.V.s of 10-15, we have concluded that we need to look at our C.V. recommendations and relate them to field demonstrated results.

Roundup Study: % Weed Control

Herbicide Rate	10L/ha			30L/ha			50L/ha		100L/ha		100 L/ha Bike
% RR*	Sm*	Hy*	Lg*	Sm	Hy	Lg	Sm	Lg	Sm	Lg	Lg
25	84	97	-	-	97	68	87	97	84	67	93
50	90	99	-	97	99	96	97	100	100	95	97
75	98	100	-	100	100	96	99	-	100	99	100
100	100	100	-	100	98	99	100	100	100	-	100

*(Sm) Small drops 130 µm MVD, Air Assist Nozzles AJ.016TK3 C.V. 9
140 µm MVD, Air Assist Nozzles AJ.020TK5 C.V. 12
*(Hy) Hydraulic ≈200 µm MVD, Spraying Systems 800025TC C.V. 50
*(Lg) Large Drops 410 µm MVD, Spraying Systems 80015LP C.V. 16
*(%RR) Recommended Rate .267 kg ai/ha, & .05% Agrol 90 by vol

Wild Oat Herbicide Study

The results presented are an average of 7 large trials, using 4 different wild oat chemicals (diclofop-methyl, [Mataven],flamprop-methyl [Hoe-Grass], sethoxydim [Poast], fluazifop-butyl [Fusilade]) on various labelled crops.

Wild Oat Herbicide Study: Weed Control 0-9 Scale

	30 L/ha		50 L/ha		100 L/ha		**Water Volumes**
% of Rec. Rate	Sm *	Lg*	Sm	Lg	Sm	Lg	**Drop Size**
25%	5.2	1.8	4.4	3.2	4.5	3.9	
50%	6.7	4.6	6.3	6.2	6.8	7.0	
75%	8.3	6.6	8.4	7.5	8.4	8.3	
100%	8.8	7.6	8.9	7.8	8.8	8.8	

* Sm - small drops
* Lg - large drops

Results: Large and small drops give similar control levels at the 100 L/ha volumes, even though the small drop application produces many more times the number of drops than the large drop applicator. At this water volume, it would appear that we are well above the coverage threshold and thus, there is no response to increased drop numbers. When the water volumes are reduced down to 50 L/ha and 30 L/ha, control levels of the large drop application fall, but the small drop applications are continuing to provide the same control levels of the 100 L/ha applications. The water volume used can vary between 30 L/ha and 100 L/ha, provided that coverage levels are maintained by keeping drop number at or greater than the conventional rate. **Water volume reductions in conjunction with a reduction in drop sizes, which increase drop numbers, maintain coverage levels and control.** Generally, herbicide rate reductions will give similar levels of control with low water volumes and small droplets had the same reduction been applied with large droplets at 100 L/ha.

Fusilade Study

Fluazifop-Butyl was applied to flax 2->3" high with wild oats in the 3->4 leaf stage at the recommended rate of .25 Kg/ha and 25,50 and 75% of that rate.

Fusilade Study: Weed Control 0-9 Scale

Fluazifop-butyl	30L/ha		50L/ha		100L/ha		Water Volumes
Kg/ha	Sm	Lg	Sm	Lg	Sm	Lg	Drop Size
.063	8.2	0	5.7	1	5.3	1	
.125	8	0	7.9	1	7	4.5	
.188	9	4	8.9	3.7	9	8.8	
.25	9	5	9	5	9	9	

Results: Both large and small drops give excellent control levels at .25 kg/ha rate in 100L/ha. When the water volumes are reduced to 50 & 30L/ha, the **control with the large drop application falls to an unacceptable level, while excellent control is maintained with the small drop application**, because good coverage levels are also maintained. When the rate is reduced down to .125 & .063 kg/ha in 100L/ha, the control drops off to a greater extent with the large drop application This indicates that even at this relatively high water volume the level of coverage can be improved upon with small drops. At the lower chemical rates, as the water volumes are reduced, the small drop applications give an increased level of control over large drops. The data indicates that control levels with fluazifop-butyl is a function of two variables. The product appears to be extremely sensitive to coverage, but it has also responded to a more concentrated drop. Reduced water volumes, producing the concentrated drop and coverage maintained by large numbers of small drops, show a great deal of promise for this particular product.

Fig. *1, Shrouded Plot Sprayer towed by a Yamaha Quad Runner

Table 1, Drop Size/Drop Number/Tip/PressureTable

Drop Dia MVD µm	#Drops/L x 10^6	L/ha	Drops/ha x 10^6	Tip Size	Pressure kpa
100	1912				
130	870	10	8700	TK3 Air Jet	200
180	327	10	3270	800025	410
200	238	10	2380	800040	410
250	122				
280	83				
300	70	30	2100	800067	200
340	49	50	2450	8001	410
370	38	50	1750	8001	200
380	35	50	1900	80015LP	200
400	30				
410	28	100	2800	80015LP	100
480	18	100	1800	8002LP	100
500	15				

Table #2, Nozzle Flow Rates (liter/minute)

Pressure kpa	AJ.016TK3	AJ.020TK5	800025	800040	800067	80015LP
@ 100						.56
@ 207	.140	.206	.09	.140	.22	.79
@ 250					.24	.88
@ 275	.162	.245				
@ 300					.26	
@ 350	.181	.277				
@ 410	.198	.297	.117	.185	.31	
@ 690			.149	.235		

Table #3: Coefficients of Variation for Listed Tips.

Tip Size	Pressure (KPa)	Height (mm)	Flow Rate (L/m)	C of V
AJ.016TK-3	207	355	0.138	8.82
AJ.020TK-5	207	355	0.205	11.7
800017TC	690	355	0.088	62.2
		457	0.104	43.6
800025TC	207	355	0.089	86.6
		457	0.090	66.6
		559	0.091	56.8
	414	355	0.117	50.1
		457	0.120	33.0
		559	0.119	23.0
	690	355	0.149	34.3
		457	0.149	19.8
		559	0.150	16.4
800040	207	355	0.137	56.1
		457	0.137	42.0
		559	0.137	31.5
	414	355	0.183	34.3
		457	0.185	23.4
		559	0.191	18.5
	690	355	0.237	25.3
		457	0.231	20.7
		559	0.232	13.8
80^{0}LF.4	207	355	0.143	72.4
	414	355	0.183	52.2
		457	0.181	45.7
80015LP	104	355	0.625	16.2
		457	0.590	12.1
		559	0.622	8.01
	276	355	0.947	9.40
		457	0.952	7.92
		559	0.946	7.55

Table # 4: Application/Speed/Tip/ Pressure Table

Large Drops

Rate L/ha	Tip No.	Speed km/hr	Pressure kpa	Drop Size µm
30	80015LP	22	100	410
50	80015LP	13	100	410
100	80015LP	6.5	100	410

Small Drops

Rate L/ha	Tip No.	Liq.Pres. kpa	Air Pres. kpa	Speed km/hr	Drop Size µm
10	AJ.016TK3	207	69	16.8	130
10	800040	207	-	22	≈ 205
10	800025	350	-	14.2	≈ 180
30	AJ.016TK3	229	69	5.9	130
30	800040	207	-	7.6	≈ 205
30	800025	410	-	7.4	≈ 180
50	AJ.020TK5	229	69	5.9	≈ 140
100	AJ.020TK5+	410	69	5.9	≈ 140
	AJ.016TK3	410	69		

Acknowledgement

The authors would like to thank Agriculture Canada and Supply & Services Canada for funding this research program. We also thank Dr. Brian Drew, Dr. Ross Ashford, and Bill Reed of the University of Saskatchewan for their support and consultation. Also, Alvin Mitchell for his evaluation work and Roy Maki, Brent Rinholm for their assistance on this project.

BILIOGRAPHY

AMBACK, R.M., ASHFORD, R: Effects of Variations in Drop Makeup on the Phytotoxicity of Glyphosate; Weed Science, Vol 30, 221-224, 1982

BEHRENS, R: Influence of Various Components on the Effectiveness of 2,4,5-T Sprays; 1957, Weeds Vol.5, No.1

BUEHRINGS, N.W., ROTH, L.O., SANTELMANN, P.W: Plant Response to Herbicide Spray Drop Size & Carrier Volume; Trans ASAE Vol 16, No.4, p.p. 636-638, 1973

BYASS, J.B., LAKE, J.R: Spray Drift from a Tractor-powered Field Sprayer; Pesticide Science 1977/8, 117-126

COMBELLACK, J.H.., RICHARDSON R.G: Effect of Changing Droplet Trajectory on Collection Efficiency Symposium on Application and Biology, British Crop Protection Council (1985, In Press)

HIMMEL, C.M: Analytical Systems for Pesticide Spray Transport & Impingement; ASAE Summer Meeting 1982 Paper No. 82-1001

HISLOP, E.C: Crop Spraying: The Need for Scientific Data, SPAN Vol 26, 1983

PCHAJEK, D.G., CAMPBELL, D.C: Evaluation & Comparison of the Spinning Disc (CIDA) & Low Pressure Nozzles with Conventional Flat Fan Nozzles; S.W.P., Product Development Field Test Report, 1982

REICHARD, D.L., TRIPLETT, G.B: Paraquat Efficacy as Influenced by Atomizer Type; Weed Science, Vol 31, 1983

ROGERS R. B. & FORD, R. J: Development of the Windproof Sprayer: presented to the ASAE Summer Meeting 1985, Paper No. 85-1003.

SPRAYING SYSTEMS CO. DWG. #12135-63 & 12135-17

THREADGILL, E.D., SMITH, D.B: Effects of Physical & Metereological Parameters on the Drift of Controlled-Size Droplets; Transactions ASAE Vol 18, No.1 p.p. 51-56. 1975

TODD, B.G: Usage of Wild Oat Herbicides Across the Prairies; Manitoba Department of Agriculture Report